EHC 12-16 May 2024 Bucharest, Romania

EUROPEAN HORTICULTURE CONGRESS

S07: URBAN HORTICULTURE: FROM VERTICAL FARMING TO PLANTING DESIGN

Conveners:

Prof. Dr. Leo Marcelis (leo.marcelis@wur.nl)

Prof. Dr. Trine Hvoslef-Eide (trine.hvoslef-eide@nmbu.no)

Assoc. Prof. Dr. Ioana Tudora (ioana.tudora@horticultura-bucuresti.ro)

S07: URBAN HORTICULTURE: FROM VERTICAL FARMING TO PLANTING DESIGN; BUCHAREST, EHC2024, MAY 13-16

ORAL PRESENTATIONS

SESSION I: URBAN DWELLING AND (IN)FORMAL LANDSCAPE DESIGN

S07-O-I-1

Design-mediated food commons in mass housing estates: the R-Urban experience

Petrescu, D. *(Invited Speaker)*

15 Rues Marc Seguin, 75018 - Select - Paris, France; d.petrescu@sheffield.ac.uk

This paper addresses aspects concerning the emergence of urban farming in mass housing estates in France. Amongst different aspects, we focus on the potential role of urban farms as new forms of commons which reconnect citizen with nature and increase civic resilience. The question of commons is related to the many major challenges we face today notably the lack of democratic control over the (planet) resources and resilience in face of the multiple crises related to Climate Change. Urban commons can contribute with solutions to the complex process of transition towards more resilient forms of governance at different scales, from the neighbourhood to the city, the region and further on. In the context of mass housing estates, enabling the emergence of commons, and more specifically food commons, can be a resilient alternative to the current urban regeneration approaches. This process needs agencies and actors, and architects and landscape designers can play an important role.

In order to provide an example in this sense, we take the case of R-Urban, a project initiated by atelier d'architecture autogérée as a commons-based network of civic resilience implemented in Parisian suburbs. The network consists in resilience hubs, many of them focussed on food and located in mass housing estates, which are collectively managed by inhabitants. The hubs whose infrastructure has been designed by architects and landscape designers, function as forms of urban commons, constituting an alternative to the publicly funded 'collective equipment' currently existing in mass housing estates through government housing programmes since the late 1950s and 1960s. As opposed to these 'equipments', the R-Urban hubs are self-managed, being run and funded mainly with civic contribution. 10 such hubs have been built in suburban neighbourhoods in Paris and London in the last decade connecting different initiatives, including food related practices through locally closed circuits. As such, energy is produced locally, grey water is collected and depolluted, waste is transformed, food is produced locally etc… reducing by 40% the ecological footprint of the neighbourhood and increasing the economic and ecological returns to the community.

The network of hubs create as such important social, ecological and economic values which contribute to the welfare of the community, the state and ultimately the planet.

Keywords: Food commons; urban commons; R-Urban; civic resilience hubs; architecture and landscape design; social, ecological and economic values

S07-O-I-2

What does 'sustainability' mean for home gardens? Exploring the perspective of garden owners

Lehberger, M., Weinrich, D., Pizzini, L., Sparke, K.

Professorship Horticultural Economics, Geisenheim University, Geisenheim, Germany; mira.lehberger@hs-gm.de

There is a growing scientific interest in home gardens and their impact on sustainability. While scientists often focus on a specific aspect of sustainability, the perspective of the garden owners themselves is often overlooked. This is where the present study comes in. We collected data from an open-ended question in an online survey with n= 262 participants and data from two focus groups with n=12 participants to explore garden owners' perspective on the sustainability of gardens. We analyzed the data using content analysis. From the survey data we find that home gardeners defined sustainability of gardens mainly in terms of environmental aspects, such as not using chemical-synthetic pesticides and protecting nature. Some economic aspects were also mentioned, such as cultivating food in home gardens. Participants of the two qualitative focus groups were asked to specifically discuss the sustainable impacts of gardens in all three dimensions. In the environmental dimension, very similar aspects were mentioned as in the online survey. In the social dimension, various leisure activities in the garden and the positive impact of gardens on health were discussed. The economic dimension included both positive and negative impacts, such as the various costs associated with maintaining a garden. Our research is the first to explore the meaning of sustainable home gardens from garden owners' perspective.

Keywords: Private gardens, sustainable gardening, urban gardening, definitions

S07-O-I-3

Studies on the behavior of peri-urban Iasi inhabitants towards decorative vegetable gardens

Istrate, A-M-R., Stoleru, V.

3, Mihail Sadoveanu Alley, Iasi, Romania; roxanah@uaiasi.ro

Motivated by the rapid urban expansion and the desire to integrate aesthetic design with functional utility in constrained areas, this study explores the transformative potential of decorative vegetable gardens within the peri-urban regions of Iasi. This study aimed to measure the residents' awareness, interest, and available resources concerning ornamental vegetable garden concepts. In this way, we used a detailed questionnaire to gather information on individuals' existing knowledge, preferences, and aspirations to design an exceptional garden tailored to their needs. Preliminary findings suggest a promising enthusiasm for these innovative gardening practices, underscoring the importance of tailored educational initiatives. This research presents invaluable insights for horticulture enthusiasts and professionals alike, paving the way for sustainable urban practices attuned to peri-urban communities' unique characteristics and needs.

Keywords: Peri-urban horticulture, Decorative vegetable gardens, Urban expansion, Horticultural education, Sustainable urban practices

S07-O-I-4

Landscape as quality value for the socialist urban districts in Craiova

Trif, A.

Vasile Alecsandri 15, 200676 Dolj Craiova, Romania; andreeatrif@ymail.com

The socialist residential districts followed similar concepts as the modernist ones, but the quality was influenced by the economic stress and by ideological values. In the post-socialist period, the property rights conflicts and the lack of vision determined new problems. The quality of public spaces and the green resources are menaced by continuous fragmentation and pressure of chaotic developments.
We will try to understand the public space quality through studying the evolution of the socialist districts in the recent period. Based on observation of the landscape quality and the spatial configuration of the public realm, we hope to present the main dysfunctions and the impact upon life quality in our districts.
We will present the data collection and the results of two years of student projects in the Faculty of Horticulture from Craiova. The main instruments for our approach were:
- the uses and spatial integrity of green spaces,
- the spatial fragmentation of public space and the real-estate pressure
- the public spaces functions distribution in the district
- the physical limits of public spaces – fences, obstacles.

As conclusion, offering the results of two city areas we will compare the dysfunctions effects and try to extract the efficacity of the research approach.

Keywords: Landscape, residential districts, public space quality

SESSION II- LANDSCAPE AS CULTURAL AND SOCIO-ECONOMIC VALUE

S07-O-II-1

From monastic gardens to urban gastronomy: tracing the evolution of kitchen gardens reaching the Chef's restaurants

Nicola, S., Petrini, A., Devecchi, M.

University of Turin, Dept. of Agric., Forest and Food Sciences, Leonardo Da Vinci 44 (L.Paolo Braccini, 2), 10095 Grugliasco (TO), Italy; silvana.nicola@unito.it

Relying on homegrown produce has remained a constant throughout history, offering a significant contribution to self-sustainability. Kitchen gardens, known as potagers, have manifested in various forms across different eras. In medieval times, monastic gardens played a crucial role, ensuring both sustenance and medicinal supplies by cultivating not just vegetables and fruits, but also aromatic and medicinal plants. This tradition extended to royal kitchens within castles, where dedicated spaces were allotted for cultivation. Despite the expansive opportunities presented by global trade, the essence of kitchen garden culture persists. Urban gardens have become a common sight in cities, and their presence extends beyond unexpected places such as restaurants, schools, and hospitals. While the species cultivated may differ from historical choices, the desire for self-produced food remains an enduring aspiration. Furthermore, modern horticulture in

these settings has unveiled intriguing new facets. Community gardens, for example, offer not only fresh produce but also health benefits such as stress alleviation and enhanced social interaction. Urban gardens provide one of the most important contributions in terms of ecosystem services to cities. Restaurants incorporating kitchen gardens exemplify a "field to table" and "zero-time postharvest" approach, not confined to rural areas but also embraced in cities through rooftop gardens and greenhouses. Here, gardens transform into pivotal elements shaping the ambiance, providing patrons with an emotionally resonant dining experience. Chefs draw inspiration from their immediate surroundings, crafting menus attuned to the seasonal offerings of the cultivated plants. The availability of fresh, high-quality vegetables, herbs, fruits, and flowers, tailored to specific needs and seasons, empowers restaurants to stand out amidst competition, offering a distinctive culinary experience. The evolving landscape of kitchen gardens not only sustains a historical tradition but also fosters innovation, promoting healthier living and enriching the tapestry of gastronomy.

Keywords: Urban landscape, urban planning, garden heritage, fresh produce, food heritage, from field to table, zero-time postharvest

S07-O-II-2

Greening the cities of Romania. A survey of the intentions, projects, specialists and nurseries in the 19th and early 20th centuries

Mexi, A.

Calea Victoriei 12 C, Bucharest, 030026 Bucharest, Romania; alx.mexi@gmail.com

The Organic Regulations of 1831 and 1832 provided the first legal instruments for the “modernization” and “beautification” of the Romanian cities south and east of the Carpathians. Local, but particularly foreign specialists were called by the rulers of the country and/or the municipalities to come and work in cities from the two Romanian Principalities of Moldavia and Wallachia and helped transform the image of the urban habitats. They created projects for urban (re)development, housing, parks and gardens, urban plantings etc., were involved in the implementation and/or monitoring of such projects and further supervised the maintenance of these works.
Based on archival information from public and private archives from Romania and abroad (London, Paris, Vienna, Rome, Brussels), the following paper will look into the official/public intentions for greening cities south and east of the Carpathians in the 19th and early 20th centuries, the projects designed particularly by French, German, Austrian or Swiss specialists for this purpose and the collaboration with Romanian and foreign nurseries involved in the implementation and even further maintenance of public parks and gardens or tree-lined avenues. Also, the paper will emphasize on the cultural value of the remnants of ancient works of urban greening and the ways in which such physical witnesses should be preserved for the future.

Keywords: Organic Regulations, urban greening, cultural heritage, historic gardens, public parks, historic urban planting

SESSION III - ROOT ZONE, WATER AND NUTRIENTS IN URBAN HORTICULTURE

S07-O-III-1

Se biofortification of *Ocimum basilicum* L. var. Italicum and Violetto plants in a Micro-Indoor Farm

Profico C.M.[1], Fatahi, S.[2], Rabiei, V.[2], Ertani, A.[1], Nicola, S.[1]

[1] Largo Paolo Braccini 2, University of Turin, Department of Agricultural, Forest and Food, I-10095 Grugliasco TO, Italy; cosimomatteo.profico@unito.it

[2] University of Zanjan, Department of Horticultural Science, P. O. Box 45371-38791, Zanjan, I. R, Zanjan, Iran;

Selenium (Se) deficiency in animals is often associated with health disorders, including oxidative stress-related conditions, cardiovascular disease, reduced fertility, and an increased risk of cancer. Concern has arisen due to the diminishing or low Se status in soils certain regions worldwide, particularly in select European countries. In this study, *Ocimum basilicum* L. var. Italicum and Violetto plants were grown in a Micro-indoor (MitTech) Plant Factory with Artificial Light (PFAL) using a floating growing system and treated with sodium selenate at concentration of 0 (control plants), 5 µM, 10 µM, and15 µM through foliar application. The LED spectrum consisted of 13% blue, 15% green, 61% red and 11% far-red (1B:4R ratio). The PPFD was set at 255 µmol m−2 s−1 with a photoperiod of 14 hours. To comprehensively assess the effect of Se on basil, various parameters such as biometric data, yield, nutritional status, total phenols, chlorophyll, anthocyanins, proteins, stomal conductance (gsw), photosystem II efficiency (PhiPS2), and evaporation (E) were evaluated. The highest yields were obtained in both green and red basil plants when grown with 10 µM Se (2740 g m-2 and 3282 g m-2, respectively). In both varieties, the values of PhiPS2 and gsw in plants treated with 10 µM sodium selenate showed slight differences compared to those of the control plants. The chlorophyll content exhibited a statistically significant increase in both green and red basil plants, with values rising by 25% and 15%, respectively, compared to the control plants. The preliminary results obtained in this study suggest that soilless cultivation systems are suitable for enriching plants with beneficial elements such as Se. Further analysis of chemical data will be crucial in understanding the effects of Se on basil plants and will be presented.

Keywords: Selenium application, aromatic plants, soilless cultivation, floating growing system

S07-O-III-2

Hydroponic and aeroponic cultivation of lettuce in urban green roof systems using either nutrient solution or grey water

Daliakopoulos, I.N.[1], **Nektarios P.A**.[2] , Harkoutsis, D.[2], Paradimitriou, D.[1], Daskalaki, C.[2], Markakis, N.[1], Manios, T.[1]

[1]*Utilization of Natural Resources and Agricultural Engineering Laboratory, School of Agricultural Sciences, Department of Agriculture, Hellenic Mediterranean University, 71004, Crete, Greece;*

[2]*Quality and Safety of Agricultural Products, Landscape and Environment Laboratory, School of Agricultural Sciences, Department of Agriculture, Hellenic Mediterranean University, 71004, Crete, Greece; nektarios@hmu.gr*

Green roof systems (GRS) are popular for the re-introduction of the urban lost flora. However, their usage on building retrofitting is limited due to the additional weight exerted on the building framework. The present study evaluated the use of lightweight hydroponic and aeroponic systems as GRS irrigated either with hydroponic solution or with greywater. Fourteen outdoor high-tech lysimeters with internal dimension of 2 × 1 m were used to grow lettuce (*Lactuca sativa* Cos Doris (Dover)) and treatments included (a) a hydroponic system with bags filled with agricultural perlite as growing medium, (b) an aeroponic system using a polystyrene cap as container allowing the unrestricted development and mechanical support of the root system in the air, (c) irrigation with modified Hoagland nutrient solution and (d) irrigation with greywater collected from a private house. Each treatment was replicated 3 times (2 systems × 2 irrigation sources × 3 replications = 12 lysimeters). In each lysimeter, 18 lettuce plants were planted. Four additional lysimeters served as unplanted irrigated controls and two empty lysimeters simulated a conventional rooftop, totalling 18 lysimeters. Measurements were performed in 4 central plants within each lysimeter and included plant height and growth index, leaf stomatal conductance, SPAD, leaf fluorescence, pH, and EC of the effluent. The weight fluctuation of each treatment was determined using weighing lysimeters equipped with load cells in conjunction with real time effluent volume determination using tipping buckets. Weighing was averaged though a junction box and transmitted using Arduino while tipping bucket data was transmitted through PLC. Results show that the surface density of the aeroponic system was 5.4-8.3 kg m-2, while that of the hydroponic system varied between 26.1-45 kg m-2. Lettuce growth was promoted using hydroponic compared with the aeroponic system and greywater was proved to be inadequate for plant growth. The growth results were supported by SPAD and leaf fluorescent and stomatal conductance measurements. The drainage pH and EC for greywater (7.5-9.9 and 0.6-0.7 dS m-1, respectively) and nutrient solution (5.8-7.0 and 1.7-1.8 dS m-1) remained within the acceptable range for lettuce growth. Based on the current study, the hydroponic system using modified Hoagland nutrient solution was the only acceptable treatment for lettuce growth.

Keywords: Adaptive green roof systems, Mediterranean zone, substrate depth, substrate type, native plant species, deficient irrigation, drought tolerance.

S07-O-III-3

Root exudation rates of three leafy vegetables under different light qualities

de Haas, B.R.[1], Indeche, A.[2], Geelen, D.[1], Dhooghe, E.[1]

[1]*Department of Plants and Crops, Faculty of Bioscience Engineering, Ghent University, Belgium, brechtje.dehaas@ugent.be*

[2]*Department of Horticulture and Food Security, School of Agriculture and Environmental Science, College of Agriculture and Natural Resources, Jomo Kenyatta University of Agriculture and Technology, Kenya*

Vertical farming may increase the diversity of ways to produce food. Within vertical farms, many environmental factors can be controlled for optimum growth conditions. While the effects of these environmental factors are relatively well-understood for their impact on aboveground growth, very little is known about belowground processes. In this article, we will study the effects of light quality, and specifically monochromatic red light on the root exudation of three leafy vegetables: lettuce, arugula and watercress. Plants were grown in deep flow culture, and exudate was collected 24 days after transplanting. Total exudation rates of C, carbohydrates and phenolics were determined spectrophotometrically. Red light significantly ($p < 0.05$) increased the total C exudation rate for the three leafy vegetables. The carbohydrate exudation rate tended ($p < 0.1$) to be higher for watercress, compared to lettuce and arugula. The phenolic exudation rate of watercress was always three- to four times higher than that of lettuce or arugula, respectively. Moreover, the relative contribution of unidentified compounds increased with red light. So, red light changes exudation rates both quantitatively and qualitatively in leafy vegetables. It seems that carbohydrate exudation rates are stable in leafy vegetables in deep flow culture. The exudation rate of phenolics is species dependent, but net exudation rates are also light quality dependent.

Keywords: Root exudate, hydroponics, leafy vegetables, light quality

S07-O-III-4

The impact of growing conditions on the yield and quality of various lettuce varieties cultivated in the NFT system in greenhouses and under LED lighting

Draghici, E., Cojocaru (Jerca), E., **Dumitrașcu, D.,** Jerca, I.O., Chira, L., Dobrin, E., Chan, S.

University of Agronomical Sciences and Veterinary Medicine, Bucharest, Marasti 59, Romania, denisa.dumitrascu@horti.usamv.ro

In the unconventional NFT system, a variety of short-growing green vegetables can be cultivated, offering benefits in terms of commercial viability, nutritional quality, and biochemical content. In this study, we utilized different varieties of lettuce as biological materials. The combination of differentiated fertilization and LED lighting in the NFT system can offer significant benefits in terms of the quality and quantity of vegetable production, thereby contributing to more efficient and sustainable agriculture. Studies in this field may explore the effects of different fertilization and lighting regimes on aspects such as nutrient content, antioxidants, flavour, and texture of the lettuce.
The objective of our research was to assess the growth of these species in the NFT system under LED lighting conditions, conducted at the Plant Factory of the Faculty of Horticulture, UASMV Bucharest.

Keywords: Lettuce, Leds, fertilisers, biochemical content

S07-O-III-5

Effects of wastewater and gray water irrigation on *Aptenia cordifolia, Carpobrotus edulis, Festuca ovina glauca* and *Ophiopogon japonicus* treated with growth promoting bacteria in external green wall

Jozay, M.[1], Zarei, H.[1], **Khorasaninejad, S.[1],** Miri, T.[2]

1 Horticultural Sciences, Faculty of Plant Production, Gorgan University of Agricultural Sciences and Natural Resources, Gorgan, Iran; Corresponding Authors: khorasaninejad@gau.ac.ir; skhorasaninejad@yahoo.com; h.zarei@gau.ac.ir

2 School of Chemical Engineering, University of Birmingham, B15 2TT, United Kingdom

The need to use non-conventional water sources for agricultural irrigation can be used to reduce consumption of fresh water and the need for mineral fertilizers. The main purpose of this study to manage water in green walls by examining the effects of morphophysiological and biochemical characteristics of the ornamental *Aptenia cordifolia*, *Carpobrotus edulis*, *Festuca ovina* glauca and *Ophiopogon japonicus* irrigated with recycled water. The experiments followed a split-plot layout, organized within a randomized complete block design with three replications from March to December 2022 on an external green wall. The main factor was recycled waters with three levels (gray water, wastewater effluent from the Kashfroud region of Mashhad, and urban water (control).). The sub-factor included different bacterial strains at four levels, composed of various bacteria combinations, (B1: *Psedoumonas flucrecens+ Azosporillum liposferum+* accumulator plant, *Thiobacillus thioparus+ Aztobactor chorococcum*, B2: *Paenibacillus polymyxa+ Pseudomonas fildensis+ Bacillus subtilis+ Achromobacter xylosoxidans+ Bacillus licheniform*, B3: *Pseudomonas putida+ Acidithiobacillus ferrooxidans+ Bacillus velezensis+ Bacillus subtilis+ Bacillus methylotrophicus+ Mcrobacterium testaceum*, and the control level without bacterial application (B0).The results indicated that all morphophysiological traits (growth index, plant coverage, Relative water content (RWC), electrolyte leakage (EL), chlorophyll and biochemical traits (total protein, and activity of antioxidant enzymes) showed significant differences at a 5% probability level. Moreover, superior morphophysiological traits were observed in plants cultivated in substrates inoculated with wastewater irrigation. The highest Relative water content (RWC) and chlorophyll, along with the lowest electrolyte leakage (EL) were observed in substrates inoculated with bacteria. Furthermore, plant growth-promoting rizobacteria (PGPR), from a biochemical traites, were associated with increased total protein. They also contributed to controlling oxidative stress caused by free radicals by enhancing the activity of antioxidant enzymes. The results of this research use MIX B3 (*Pseudomonas putida + Acidithiobacillus ferrooxidans + Bacillus velezensis + Bacillus subtilis + Bacillus methylotrophicus + Microbacterium testaceum*), and irrigation with waste water, as well as it also suggests the use of *A. cordifolia* instead of other unstable plants used in the external green wall in dry and semi-arid climates.

Keywords: Growth index, Oxidative stress, Ornamental plant, Recycling water, Relative saturation deficit.

SESSION IV-VERTICAL FARMING AND SUSTAINABILITY

S07-O-IV-1

Vertical farming sustainability reporting: Performance, insights, and politics

Martin, M. *(Invited Speaker)*

Lilla badvägen 9, kersberga, Sweden; michael.martin@ivl.se

Vertical farming systems often claim to provide promising solutions to secure food supplies and produce more sustainable food. However, little is known about their sustainability and performance compared to products from conventional sourcing. This has led to an increase in the number of claims being employed to motivate the validity of vertical farming systems by producers. As such, there has been an increasing interest in sustainability assessments of vertical farming employing, e.g., LCA. Furthermore, several recent sustainability assessment frameworks and standards for vertical farming sustainability and accountability have been developed. While many of the current assessments and standardization frameworks have good intentions for promoting more sustainable production in the field, the political nature of what entails a 'sustainable' vertical farming production system remains unclear. This study is based on a triangulation of applied research, 1) conducting life cycle assessments for vertical farming producers, 2) from experience in a role as a scientific advisor for several developing sustainability standards for vertical farming, and 3) through document analyses of sustainability claims of vertical farming performance. This study provides insights into the life cycle management work within vertical farms at different scales and contexts from experience working with vertical farming companies and outlines the developing ‘techno-politics’ of sustainability reporting and standardization. As such, the study provides an objective review of how sustainability is both ‘used and misused’ in the field to promote vertical farming as a sustainable production method. The results provide valuable insights to current and developing vertical farming firms on how life cycle methods can be used to improve the environmental performance of their operations and how to navigate different sustainability standards and frameworks for more transparent sustainability reporting.

Keywords: Vertical farming, LCA, sustainability, reporting, policy, standards

S07-O-IV-2

Assessing the sustainability claims of sunless vertical farming

Katzin, D., Stanghellini, C.

Wageningen Research, Greenhouse Horticulture and Flower Bulbs, PO Box 644, 6700AA Wageningen, Netherlands; david.katzin@wur.nl

Vertical farming in highly controlled and sunless environments has been suggested as one of the possible solutions to promote the sustainability, availability, and quality of food for a growing and urbanizing population. Some of the promoted benefits of vertical farming include high yields, high land use efficiency, high water use efficiency, and reduced use of chemicals, with minimal pollution to the outside environment. Using some basic laws of physics and physiology, we quantify what is actually achievable in vertical

farms in a best-case scenario. We show that the energy use of vertical farms is substantially higher than in greenhouse production, and several orders of magnitude higher than in open field production. A trade-off exists between water use and energy use: the most meaningful component of water savings achievable in sunless farms is only possible through mechanical dehumidification, which requires large amounts of energy. We show that investing energy in order to conserve water would often better be done by desalination. Lastly, we provide some basic calculations to demonstrate that in the majority of cases, producing vegetables in an open field and transporting them by truck would cause less greenhouse gas emissions than producing vegetables locally in a sunless farm.

Keywords: Controlled environment agriculture (CEA), Indoor farming, LED & electricity, Light productivity, Light use efficiency, Urban agriculture, Sustainability, Energy use, Greenhouse gas emissions

S07-O-IV-3

Efficient Vertical Farming: The Role of Operations Management Models and Research Opportunities

Alikhah, S.[1], **Sharifyazdi, M.[2]**, Rudi, A.[1], Schultmann, F.[1]

[1]*Karlsruhe Institute of Technology, Karlsruhe, Germany;*

[2] *BI Norwegian Business School, Oslo, Norway; mehdi.sharifyazdi@bi.no*

Vertical farming, a relatively recent development in agriculture, introduces innovative methods for stable and localized food production within controlled, constrained settings, thereby distinguishing it from traditional farming methods. On one hand, this strategy holds substantial promise for enhancing sustainability and efficiency through the conservation of water, optimization of land use, localized production and distribution of food, increased output in limited spaces, and sustainable production practices. On the other hand, operations management, which is essential for efficiency in organizations and supply chains, includes methodologies that enhance performance at strategic, tactical, and operational levels. Central to this domain are decision-support mathematical models aimed at optimizing supply chain processes including supply, production, control, storage, distribution, and more. These models focus on goals like maximizing profitability, reducing production time, lowering carbon emissions, minimizing transportation, improving product quality, reducing waste, increasing resource efficiency, and aligning supply with demand, among others. However, due to the relative novelty of vertical farming and its unique characteristics in supply and value chain, there is a notable lack of research on adapting current operations management models and creating new ones for this context. Given the unique aspects of vertical farming processes, this study explores and suggests potential pathways for developing specialized operations management models that cater to the specific requirements and constraints of vertical farming systems to boost operational efficiencies and support sustainable growth in this sector. This includes creating frameworks that integrate the distinct needs of vertical farming, ensuring that these models optimize resource use and production in alignment with sustainable farming practices. This study, through a literature review, aims to bridge the gap between traditional operations management techniques and the distinct

challenges of vertical farming, laying the foundation for future advances in agricultural management.

Keywords: Vertical Farming, Operations Management, Operations Research, Supply Chain Optimization, Decision-Support Models, Strategic Planning, Tactical Planning, Operational Planning, Sustainable Agriculture, Literature Review

S07-O-IV-4

Longer photoperiod combined with lower intensity: strategies to improve the growth and resource use efficiency of baby leaves grown in a vertical farm system

Zauli, I.[1], Carotti, L.[1], Pistillo, A.[1], Martin, M.[2], Pennisi, G.[1], Gianquinto, G.[1], Orsini, F.[1]

[1]*DISTAL – Department of Agricultural and Food Sciences, Alma Mater Studiorum – Bologna University, Viale Fanin 44, 40127, Bologna, Italy; corresponding author: giuseppina.pennisi@unibo.it*

[2]*IVL Swedish Environmental Research Institute, Valhallavägen 81, 114 28 Stockholm, Sweden*

Baby-leaf vegetable consumption has gained a prominent role in the food market in recent years, and they represent one of the most widely cultivated crop categories in vertical farms. Considering the novelty of vertical farming, assessments of baby-leaf cultivation with additional strategies to improve growth and resource use efficiency are needed. This study, carried out in the experimental vertical farm of the University of Bologna "AlmaVFarm", aimed at evaluating the responses of baby-leaf kale (*Brassica oleracea* L.), in an aeroponic growing system applying different lighting conditions. The environmental parameters of the growing space were set at 850 ppm of CO_2, relative humidity at 70/75 ± 10 % day/night and air temperature maintained at 24/21°C day/night. The light setting consisted of the same spectrum, a red and blue (RB) mixture with a RB ratio of 3:1 and the same daily light integral which overall provided, on average, 11.9 mol m^{-2} day^{-1}. The different light treatments consisted of different combinations of light intensities and photoperiods: 24, 20, 16, 14 hours combined with 140, 165, 210 and 235 µmol m^{-2} s^{-1}, respectively. Plants were harvested 21 days after sowing, at the baby-leaf stage. Plants cultivated under the longest photoperiod in combination with the lowest intensity (24 hours at 140 µmol m^{-2} s^{-1}) showed enhanced yield, lighting energy use efficiency and surface use efficiency compared to plants grown with the shortest photoperiod and highest light intensity (14 hours at 235 µmol m^{-2} s^{-1}). Through the insights emerging from this study, further evidence on how to improve resource use efficiency of vertical farming systems is provided.

Keywords: LEDs, aeroponic, lighting energy use efficiency, surface use efficiency, yield

S07-O-IV-5

Surplus heat generated from vertical greenhouse lighting

Brækken, A., Sannan, S.

SINTEF Energy Research, NO-7465 Trondheim, Norway; august.brakken@sintef.no

In vertical greenhouse systems, abundant lighting generates significant surplus heat, presenting an opportunity for its utilization in other applications. This study focuses on a

hybrid greenhouse in Norway, where the surplus heat from the vertical section of the greenhouse is used to heat the traditional horizontal greenhouse. The building simulation tool IDA ICE is used to estimate the amount of surplus heat in the vertical greenhouse, considering factors such as the construction, ventilation, lighting, and outdoor climatic conditions. The study period spans from December 21 to January 25 during the winter of 2023/2024. The evapotranspiration from plants was adjusted to maintain optimal thermal conditions within the vertical section. According to the model, the average daily heat removal during the period amounts to 3.6 kWh/m^2/day, closely aligned with the measured value of 3.5 kWh/m^2/day. Despite uncertainties stemming from limited and irregular data logging, as well as modeling simplifications, the model is considered to provide a reliable estimate of the available surplus heat.

Keywords: Hybrid greenhouse, building simulation, LED lights, cooling, heat pump, climate control, energy savings

S07-O-IV-6

Vertical farming for youth in rural & urban communities

Ciceoi, R.[1], Venat, O.[1], Yordanova M.[2], Dinu, M.M.[3], Gageanu, I.[3], Potra, V.[4], Tudor, C.[4]

[1] Marasti Blvd., 59, Research Center for Study of Food Quality, USAMV Bucharest, 011464 Bucharest, Romania; roxana.ciceoi@qlab.usamv.ro

[2] Assist. Prof. Milena Yordanova, Kliment Ohridski Blvd., 10, University of Forestry, 1756, Sofia, Bulgaria;

[3] 8 Ion Ionescu de la Brad Blvd., Research-Development Institute for Plant Pr, 013813 Bucharest, Romania;

[4] Principala 54, S.C Fresh Microgreens S.R.L., 107277 Fanari, Prahova, Romania;

Verti4You, an Erasmus+ project led by the University of Agronomic Sciences and Veterinary Medicine of Bucharest, involves a collaboration among Higher Education Institutions, Research and Development entities, and NGOs from Romania, Bulgaria, Greece, and Italy. It focuses on employing vertical farming and microgreens to both produce healthy food and enhance youth entrepreneurship. Additionally, the project seeks to improve social inclusion for those not in education, employment, or training (NEET) and to equip youth workers with green skills in sustainable agriculture using innovative vertical farming methods. Aligned with the European Green Deal, Verti4You encourages participants to become proactive change agents, fostering sustainable food production and environmental stewardship. This includes optimizing resource use, adopting greener lifestyles, and positively impacting their communities. The initiative included a trainers' training with 16 participants and four blended mobility sessions of 13 days each, for nearly 70 trainees aged 16-30, focusing on vertical farming from basic to advanced systems. The paper shares the achievements, challenges, and recommendations for future training activities for youth.

Keywords: Vertical farming, leafy greens, microgreens, controlled environment, youth training

S07-O-IV-7

A consistent classification of urban agriculture as prerequisite for a sound sustainability assessment

Lansche, J.[1], Mann, S.[2], Galley, S.[2], Douziech, M.[1]

[1] Life Cycle Assessment Research Group, Agroscope, Reckenholzstrasse 191, 8046 Zurich, Switzerland; jens.lansche@agroscope.admin.ch

[2] Socioeconomics Research Group, Agroscope, Tänikon 1, 8356 Ettenhausen, Switzerland

Urban agriculture is considered to have considerable potential for the sustainable production of food. However, a closer look reveals a great variability of systems labelled as urban agriculture and a limited availability of data on the sustainability of these systems. To better understand the differences between urban agriculture systems and their sustainability, this work aims at building the ground for establishing a meaningful and holistic classification of different urban agriculture systems and gathering knowledge about their environmental, social and economic sustainability. For this purpose, 93 scientific papers were reviewed. We found different approaches and perspectives for a classification of urban agriculture systems. Some approaches base the classification on the motivation of the systems' operators. These approaches characterize urban agriculture systems based, for example, on their market or production intensity or the motivation to provide social and civic benefits. Other perspectives like the urban planning, architectural or technical perspective characterize urban agriculture systems by the degree of cultivation area conditioning, building integration or technical criteria, respectively. Furthermore, we found that the environmental impacts of urban agricultural production systems reported in different studies varied by up to three orders of magnitude, partly due to the different systems and partly due to different measurement methods. We also found that non-standardized, qualitative methods have predominantly been used to describe the social and economic dimensions of sustainability, so identifying an important research gap for further development.

Keywords: Urban farming, urban food production, environmental impacts, life cycle assessment, literature review, urban gardening

S07-O-IV-8

Visual Harvest: Self-supervised learning for lettuce growth analysis

Simion-Constantinescu, A., Vanschoren J.

Eindhoven University of Technology TUe, Eindhoven, Netherlands; a.simion.constantinescu@tue.nl

Accurately estimating lettuce growth parameters is crucial for optimizing vertical farming systems, yet existing methods often rely on labor-intensive manual measurements or labeled datasets which can be scarce and costly to acquire. In this work, we propose a novel approach that leverages self-supervised learning techniques to estimate lettuce growth parameters (dry weight, fresh weight, height, diameter, and leaf area) using image data collected throughout the plant's growth cycle. Our methodology consists of a two-part pipeline. First, we implement a self-supervised pre-training step using unlabeled lettuce images obtained at different weeks since seeding. The second part involves fine-

tuning the learned weights of a ResNet18 architecture (from the self-supervised pre-training step) on a smaller labeled lettuce dataset for the regression of the 5 growth parameters. We adapt and extend two popular self-supervised learning algorithms, plantSimCLR and plantBT, tailored specifically for plant imagery. Firstly, we propose SimCLR for plants (plantSimCLR) by creating positive and negative pairs based on the time elapsed since seeding. Secondly, we introduce BarlowTwins for plants (plantBT) by applying the redundancy reduction principle to self-supervision. We apply random spatial transformations to the lettuce images to obtain two distorted versions of the original image. The self-supervised pre-training task promotes the representations of the distorted lettuce versions to be close to each other using either contrastive learning (plantSimCLR) or cross-correlation (plantBT). We evaluate the quality of the learned representation against ImageNet pre-trained weights. Our evaluation demonstrates that both plantSimCLR and plantBT provide a more effective starting point for estimating the lettuce growth parameter. Additionally, our method significantly decreases the time and effort needed for manually measuring the lettuce growing characteristics. By leveraging self-supervised learning techniques tailored to plant imagery, our work offers a promising avenue for advancing automated monitoring and optimization of vertical farming systems, ultimately contributing to sustainable and efficient agricultural practices.

Keywords: self-supervised, deep learning, lettuce growth, SimCLR, Barlow Twins

SESSION V - VERTICAL FARMING AND LIGHTING SYSTEMS

S07-O-V-1

Addition of UV, green and far-red spectra in sole-source LED cultivation of *Beta vulgaris* L. var. *cicla*

Moll, M.D.[1], Elfers, J.[1], Stoddart, D.[2], Pude, R.[1,2]

[1] *INRES–Renewable Resources, University of Bonn, Klein-Altendorf 2, D-53359 Rheinbach, Germany; m.moll@uni-bonn.de*

[2] *Field Lab Campus Klein-Altendorf, Agricultural Faculty, University of Bonn, Klein-Altendorf 2, D-53359 Rheinbach, Germany*

Sole-source LED lighting is essential for indoor vertical farming. Supplementing the red and blue spectra with different wavelengths presents multiple beneficial characteristics for crop development. Therefore, increasing the amount of green light as well as an increase in UV and far-red wavelengths available for Swiss chard was investigated. Two base scenarios were tested and each supplemented with an additional range of spectra, resulting in a total of four different LED scenarios. The first setup was a full spectrum LED with focus with higher amounts of blue. This setup was supplemented with green LEDs. The second setup was a full spectrum LED with higher PPFD in red region and full spectrum LED with added UV/far-red. The experiments were run in a controlled environment indoor farming using three different cultivars of Swiss chard (*Beta vulgaris* L. var. *cicla*): a red colored ‘Rhubarb Chard’, a red colored baby-leaf variety ‘Charlie’, as well as the white cultivar ‘Lucullus’. All three cultivars were successfully established on a Deep Water Wulture (DWC) system. Besides light spectra, no significant differences in cultivation characteristics were detected during the trial period, including pH, EC, water temperature, water oxygen-saturation, room temperature, relative humidity, carbon

dioxide concentration, and PPFD. The three cultivars showed significant differences in their growth parameters (biomass accumulation, leaf number). Photosynthetic activity significantly differed between the four LED compositions. Hyperspectral vegetation indices (VIs) revealed significant differences in plants reactions towards increased UV/far-red radiation. The results clearly indicate that a supplementation of monochromatic red-blue LEDs provides great potential in sole-source LED cultivation within indoor farming systems.

Keywords: Deep Water Culture, Swiss chard, light-emitting diodes, physiology, hyperspectral vegetation indices

S07-O-V-2

The Comparative Performance of Supplemental LED Red and Blue Light using GREENBOX Technology

Buss, G.[1], Griffith, M.[1], Carroll, P.[1], Griffis Jr. J.L.[1], Tuncay, Ö.[2], Rosen, B.H.[1], Yang, X.[3], Papkov, G.[1], Bauer, S.[4], Singh, A.[5]

[1] *Florida Gulf Coast University, 10501 FGCU Blvd S, Fort Myers Florida 33965, United States of America, gbuss@fgcu.edu*

[2] *Ege Universitesi, 35100 Izmir Bornova, Turkey*

[3] *University of Connecticut, Storrs Connecticut, United States of America*

[4] *Mercer University, Macon, Georgia, United States of America*

[5] *University of Maine, Orono, Maine, United States of America*

GREENBOX technology is a novel, low-cost, independently functioning unit capable of fresh crop production that was developed in response to increased pressures on food security, especially in urban areas. GREENBOX technology consists of individual climate-controlled units, including a thermally insulated growth apparatus, an artificial lighting source, a soilless cultivation method of hydroponics, and environmental controls. GREENBOX units may be integrated with existing urban infrastructure, such as buildings, garages, and warehouses. Previous studies have investigated the technical feasibility of lettuce *Lactuca sativa* 'Rex Butterhead' crop growth, which utilized white lighting elements. To our knowledge, no existing literature assessed the efficacy of supplementing red and blue light using GREENBOX technology. The APS Laboratory for Sustainable Agriculture aimed to fill this gap by assessing how different lighting element spectrums corresponding to red and blue colors affected the production of 'Rex Butterhead' lettuce using GREENBOX technology. We conducted comparative crop growth studies using three treatments; 1) supplemental blue light, 2) supplemental red light, and 3) no supplemental light for the white lighting element for control. The crop production cycle began with all lettuce plugs being cultivated for 15 days under the same treatment conditions. We then randomly selected plugs for transplantation to the Nutrient Film Technique (NFT) channels and lettuce was grown for an additional 30 days to full maturity, ready for harvest. We fertigated using a standard concentration nutrient solution. Each GREENBOX unit was arranged in a 4x6 configuration with 24 lettuce plants. We collected environmental data for each light treatment including temperature (°C), relative humidity (%), and carbon dioxide (CO_2) levels (parts per million, ppm). Collected biomass data included fresh weight (g), dry weight (g), and leaf area (cm^2).

Additionally, we collected chlorophyll concentration (mg/cm^2), nitrogen concentration (mg/g), leaf color (CIELAB), leaf count (n), and microbial (n) data for the red and blue treatments. We derived data that included the Leaf Area Index (LAI, cm^2/cm^2), Specific Leaf Area (SLA, cm^2/g), and Specific Leaf Weight (SLW, g/cm^2). All three treatments grew lettuce ready for harvest in the same amount of time. We observed all treatments had comparable environmental conditions upon assessment of environmental data, meeting optimal conditions required for lettuce crop production. The supplemental red light treatment produced the greatest average fresh weight per plant of 218.36 g, which was 20.59 g heavier than the white light treatment and 75.8 g greater than the blue light treatment. Plants accumulated 1.27 mg/g more nitrogen per plant under the supplemental blue light treatment than the red light treatment. Similarly, the blue light treatment resulted in a 0.005 mg/cm^2 greater chlorophyll concentration per plant than the red light treatment. An analysis of CIE-LAB correlations found that, as L (r=-0.526) and B (r=-0.608) increase, chlorophyll levels decrease ($p<0.0001$). Analysis of the nutrient solution indicated that by Day 5, there was a low-level algal contamination in the circulating nutrient solution. Results from this study may inform the future iterations of GREENBOX design.

Keywords: Controlled Environment Agriculture, GREENBOX, Hydroponics, Lettuce, Supplemental Light

S07-O-V-3

Effect of LED light spectrum on green and red lettuce cultivars grown in a vertical farm system

Hernández-Adasme, C.[1], Faicán Benenaula, M.A.[2], Guevara, M.J.[1], Sun, B.[3], Yang, X.[4], **Escalona, V.[1]**

[1]Centro de Estudios de Postcosecha (CEPOC), Facultad de Ciencias Agronómicas, Universidad de Chile. vescalona@uchile.cl

[2]Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Argentina.

[3] College of Horticulture, Sichuan Agricultural University, Chengdu 611130, China.

[4]Institute of Urban Agriculture, Chinese Academy of Agricultural Sciences, Chengdu National Agricultural Science and Technology Center, China

The light spectrum is a factor that can modify the growth and development of plants. This study investigated the impact of light spectrum on young green and red lettuce plants grown under different light spectra in a vertical farm. Green lettuce ‘Bartimer’ and red lettuce ‘Soltero’ were grown by 14 days after transplanting under three LED light spectrum treatments (UV:Blue(B):Green(G):Red(R):far red (FR) (%); R/B) named as white light (WL, 0:26:49:22:3;0.9), blue-white (BW, 0:18:39:38:5; 2.1), red-white (RW, 1:17:24:47:11; 2.8), and red-blue (RB, 1:20:8:62:9; 3.1) under photon flux of 90 µmoles m^{-2} s^{-1} and a photoperiod of 12/12. Fresh weight (FW), leaf number, total phenol concentration, and antioxidant capacity (DPPH) responded to the interaction between light and cultivar. ‘Bartimer’ significantly increased FW under WL compared to all light treatments applied to both cultivars by an average of 111%. The number of leaves was significantly higher in Bartimer grown under the WL than in the rest of the treatments. Besides, 'Soltero' under RW and WL raised the concentration of total phenols and

antioxidant capacity (DPPH) versus the rest of the light treatments applied in both cultivars by an average of 14%. On the other hand, dry matter percentage (DMP) and leaf number responded to light treatment and cultivar independently. DM increased in lettuce treated with RW compared to WL, RB, and BW by 6.9%, 17.5%, and 25.6%, respectively. Likewise, 'Soltero' exacerbated DMP compared to 'Bartimer' by 30%. The provision of RW ameliorated DMP in both lettuce cultivars and the antioxidant activity in red lettuce, improving the intrinsic quality of the lettuce.

Keywords: *Lactuca sativa* L., wavelength; antioxidant compound, in-door conditions

S07-O-V-4

Management of far-red fraction to improve lettuce yield and light use efficiency in vertical farm cultivation

Carotti, L., Zauli, I., Pistillo, A., Gianquinto, G., Pennisi, G., Orsini, F.

Alma Mater Studiorum – Università di Bologna, DISTAL – Department of Agricultural and Food Sciences, Bologna, Italy; Correspondence to: giuseppina.pennisi@unibo.it

In vertical farms and indoor farming systems, precise light management represents an opportunity to enhance growth and light use efficiency (LUE) while controlling plant morphology and quality. Red (R; 600-700 nm) and blue (B; 400-500 nm) are among the most used spectral regions in controlled environment agriculture. However, providing plants with far-red radiation (FR; 700-750 nm), in combination with shorter wavelengths (400-700 nm), triggers a series of morphological and physiological responses that could be beneficial for crop growth. The aim of this study was to construct dose-response curves with different intensities of FR radiation, in order to accurately analyse the response in terms of yield, morphology and light use efficiency for lettuce cultivation. Lettuce plants (*Lactuca sativa* var. Canasta) were grown in an ebb-and-flow system for 29 days. During the cycle, plants were subjected to 5 different light treatments, including a control treatment composed of an optimized R and B spectrum (ratio of R and B of 3, RB_3), with a photosynthetic photon flux density (PPFD) of 200 µmol m^{-2} s^{-1}, and four treatments in which 12, 35, 66 and 100 µmol m^{-2} s^{-1} of FR radiation have been added to RB_3 (namely RB_3+12, RB_3+35, RB_3+66 and RB_3+100, respectively). In all light treatments, the PPFD and photoperiod were kept constant. At final harvest, plants grown with RB_3+35, RB_3+66 and RB_3+100 had the highest leaf fresh and dry weights (LFW and LDW, respectively), as well as the greatest leaf area. While no differences were found in terms of lighting energy use efficiency (L-EUE, expressed as g LFW kWh^{-1}) between the treatments, RB_3+100 decreased light use efficiency (LUE, considered as the ratio between LDW and the moles of light in the spectrum range 400-750 nm), compared to RB_3+35. The adoption of the lighting treatments enriched with 35 to 66 µmol m^{-2} s^{-1} of FR radiation is therefore a valid strategy to increase yield and LUE for lettuce cultivation in a vertical farm.

Keywords: LED lighting, Plant factories with artificial lighting (PFALs); far-red radiation; ebb and flow

S07-O-V-5

Enhancing bioactive compound production in *Artemisia annua* through controlled environment cultivation

Paponov, M.[1], Ziegler, J.[2], Lama, P.[3], **Paponov, I.[1,4]**

[1]*Norwegian Institute of Bioeconomy Research (NIBIO), Ås, Norway; ivpa@food.au.dk*

[2]*Leibniz Institute of Plant Biochemistry, Halle, Germany;*

[3]*University of Stavanger, Stavanger, Norway,*

[4]*Department of Food Science, Aarhus University, Aarhus, Denmark.*

Medicinal plants are a vital global resource, and controlled cultivation offers a promising avenue for maximizing the therapeutic potential of phytochemicals. Growing medicinal plants in environments such as vertical farming facilities allows for the production of plants with predictable levels of biologically active compounds, crucial for the pharmaceutical industry. However, current cultivation protocols in vertical farms typically prioritize biomass production over the stimulation of secondary compound accumulation. This situation creates a dilemma: Can we grow these plants in a way that both the plant size and the chemical content are optimized? This review examines two examples of external triggers that induce the accumulation of secondary compounds with minimal impact on biomass. The first, root illumination, enhances the accumulation of artemisinin in the shoot without affecting its levels in roots. The second, heterogeneous nutrient supply, does not significantly alter artemisinin accumulation *in Artemisia annua* leaves but does increase its exudation from roots under nutrient-deficient conditions, particularly with nitrogen and phosphorus. Conversely, localized iron deficiency specifically boosts artemisinin accumulation in the roots. Future research should focus on elucidating the molecular mechanisms behind these responses and exploring additional environmental factors that can be optimized in vertical farming systems to enhance the phytochemical yield of medicinal plants.

Keywords: Secondary metabolism, hydroponics, root hairs, *Artemisia annua*, artemisinin, root lighting, split-root system

SESSION VI - URBAN REALM AND FOOD PRODUCTION

S07-O-VI-1

Food Urbanism - Integrating Agriculture into the Urban Condition

Verzone, C. *(Invited Speaker)*

Chaussée de la Guinguette 1 | CH-1800 Vevey | Suisse, verzone@vwa.ch

Urban food production is fraught with obstacles: finding available fertile land, assembling favourable conditions and nurturing competent project stewards. Thanks to intelligent planning and thoughtful proposals, food production can and does find home in the city and will increase urban quality. Codified typologies, tools, evaluation methods and strategies help conceptualize and illustrate applications of urban agriculture methods.

Five effective strategies, whether applied through professional practice or policy and planning, can encourage and develop sustainable solutions to enhance the quality of our evolving cities. This presentation aims to identify professional intentions, articulate project objectives, and raise awareness among existing and potential stakeholders. The strategies are organized around the following actions:

1. Amplify the identity of place
2. Assemble urban synergies
3. Ensure ecological benefits
4. Manage urban transformation
5. Develop landscapes of well-being

Food Urbanism aims to create new spaces that promote a harmonious coexistence between city life and food production, while considering social, economic, and environmental responsibilities. In conclusion, the Urban Agricultural Park in Geneva, Switzerland—a recently constructed pilot project—will showcase how some of these methods can be effectively implemented.

Keywords: place identity, urban synergies and transformations, ecological benefits, well-being landscapes

S07-O-VI-2

In-situ straw return, combined with plastic film use, influences soil properties and tomato quality and yield in greenhouse conditions

Yan Y.

12 zhongguancun south street, Beijing, Beijing, 100081, China; yanyan@caas.cn

To address the challenge of disposing vegetable waste in greenhouses while mitigating white pollution associated with the use of conventional polyethylene film, we compared polyethylene (PE) film with two types of fully biodegradable film in both straw-return and no-straw-return treatments. We systematically investigated the effects of mulching on soil properties, film degradation, and tomato quality and yield. The results showed that the humic acid biodegradable film with straw-return (FZS-SR) increased the contents of lycopene, vitamin C (Vc), and soluble sugars in tomato fruit by 20.77%, 16.68%, and 25.89%, respectively, and decreased the total acid content by 8.46% compared to polyethylene film with no-straw-return (PE-NR). Additionally, FZS-SR enhanced the relative abundance of soil bacteria and fungi in Chloroflexi and Basidiomycota, while reducing the relative abundance of pathogenic fungal groups. Moreover, the biodegradable film degraded 15 days earlier in the straw return treatment, with significantly higher characteristic peaks in Fourier transform infrared spectral analysis compared to no straw-return treatment. In a greenhouse, the straw-return model accelerated the degradation rate of biodegradable film. In summary, our results indicate that using humic acid biodegradable film with straw return is an effective and sustainable cultivation method, improving tomato quality and yield. This approach offers insights for addressing residual plant and film pollution in vegetable production.

Keywords: Biodegradable, film Straw-return, Tomato, Humic acid film, Lignin film

S07-O-VI-3

Comparison of Three Hydroponic Systems in Hong Kong

Zhang, A.

S1006, South Block, 133 Shing Tai Road, Cha, Hong Kong; allenzh@vtc.edu.hk

Hydroponics, a soilless cultivation method, has gained popularity in Hong Kong due to its potential to overcome the city's land scarcity and provide fresh produce to city dwellers. The demand for hydroponically grown produce has gradually increased in the last few years. The local government has promoted hydroponics as a viable alternative to traditional farming, and several hydroponic farms have emerged in Hong Kong.
In view of the governmental policy, commercial and public acceptance for hydroponics, its cultivation techniques and range of planting varieties in Hong Kong is still limited and at an early stage, thus more research works are strongly warranted. Many questions on the optimisation of the design of its operating systems and their implications for plant growth remain not clear. Therefore, it is crucial to compare the three different hydroponic systems available in the centre to collect their operating parameters for further analysis and system modification. The results would facilitate our understanding of the viability and efficiency of each hydroponic system. Moreover, the data may provide more information for further assessment of each system in terms of design, and combinations of features, which would be optimal for the unique environmental and economic conditions of Hong Kong.
This project compares the growth, yield and nutrient quality of oakleaf lettuce cultivated in the ebb-and-flow system, aeroponic system, and drip system, respectively. These systems are commonly used in the hydroponic farming in Hong Kong. In practices, each system has its own advantages and disadvantages of water utilisation, nutrient supply and delivery, and growth requirement for various food plant.

Keywords: Urban horticulture, oakleaf lettuce, ebb-and-flow system

S07-O-VI-4

Agronomical comparison of basil cultivars: vertical farming vs. conventional

Tran, D., Carron, G., Maret, M., Farinet, R., Camps, C.

Agroscope, Route des Eterpys 18, 1964 Wallis Conthey, Switzerland; qnoctnandaniel.tran@agroscope.admin.ch

By 2050 it is estimated that the human population of the Earth will be approximately 10 billion people. In order to improve input use efficiencies and mitigate greenhouse gas emissions, hydroponic production systems can represent an alternative to the conventional methods of food production.
Traditionally, leafy greens and herbs have always been associated with indoor agriculture and continue to be extremely popular among vertical farmers. More than half of indoor and vertical farms produce leafy greens. Among the grown herbs in vertical farms, basil (Ocimum sp.) represents one of the most popularly choices and is cultivated for culinary purposes as fresh herb or dried spice. It is mainly produced hydroponically or semi-hydroponically with very short growing cycles (usually 10–20 days after germination) and are considered the functional food of the 21st century.
Our objectives were to quantify productivity and characterize growth of basil cultivars grown in stacked hydroponic production systems. Twelve basil cultivars were assessed

and characterized in hydroponic conditions. Depending on cultivar, a delayed harvest time was observed with 35 to 38 days of growth after sowing seed. Basil cultivars differed greatly in fresh weight from 2.1 to 3.2 kg/m2 after one cut. The fresh weight showed a correlation with transpiration rate whereas no correlation was found with essential oil rate. In addition, a comparison between hydroponic and conventional production system have been performed on five selected cultivars. Basil cultivated in hydroponic systems displayed higher essential oil concentration compared to those cultivated conventionally in soil. Further investigations are needed to analyze essential oil composition in order to determine cultivar with a positive nutritional value.

Keywords: Hydroponic, soil, transpiration rate, essential oil rate

SESSION VII - URBAN RESILIENCE, TECHNOLOGY AND DESIGN

S07-O-VII-1

How to obtain Green, Circular, Resilient, Inclusive, Prepared, Safe and Smart cities – NOW?

Hvoslef-Eide, T.[1], Bunkholt, A.[1], Cucca, R.[2], Hegnes, A.W.[3], Jenssen, P.D.[4], Kallenborn, R.[5], Lyche, J.L.[6], Moges, M.E.[7], Remberg, S.[1], Sogn, T.[4]

[1] Norwegian University of Life Sciences, Faculty of Biosciences, NMBU, Boks 5003, 1432 Aas, Norway; trine.hvoslef-eide@nmbu.no

[2] Faculty of Landscape Society, Norwegian University of Life Sciences, P.O Box 5003, 1432 Aas, Norway

[3] Consumption Research Norway SIFO, Oslo Metropolitan University, P.O Box 4, St. Olavs plass, N-0130 Oslo, Norway

[4] Faculty of Natural Resource Management, Norwegian University of Life Sciences, P.O. Box 5003, 1430 Aas, Norway

[5] Faculty of Chemistry, Biotechnology Food, Norwegian University of Life Sciences, P.O Box 5003, 1432 Aas, Norway;

[6] Faculty of Veterinary Sciences, Norwegian University of Life Sciences, P.O. Box 5003, 1432 Aas, Norway

[7] Faculty of Natural Sciences Technology, Norwegian University of Life Sciences, P.O. Box 5003, 1432 Aas, Norway

Towards 2030 and UN's Sustainability Development Goals, solutions to feed an increasing population must be both increasing yields from existing agricultural land and increase food production in urban areas. The urban environment is polluted, polluting, and resource demanding. We must focus on developing sustainable, circular, safe, and acceptable solutions for biological wastes from the urban population to produce healthy, nutritious food within the city, based on these valuable resources. How to achieve a near-zero emission city through using recycled grey and black water from households to preserve resources and avoid expensive and polluting sewage treatment plants? Black

water mixed with other biological household waste can produce bioenergy. The residue can be used as fertiliser for plants. To capitalise on these resources, we need to evaluate circular use of black water to ensure that it is safe for public health and the environment, as well as acceptable to the public. Cultural and psychological conditions can both enable or represent barriers for change in sustainable consumption practices.
In addition to circularity, we need novel horticultural technologies for producing food in urban areas, on roof tops, walls, and vertical farming, with improved varieties. We need to improve knowledge about food production systems and technics for the general population interested in growing their own food indoors, on balconies, in backyards, allotments, and community gardens. People are eager to learn, trained urban farmers can be their mentors. At our university, a master programme in Urban Agriculture, take all these aspects into the classroom, A diverse population of students use real life cases from public municipalities and private enterprises, to solve “wicked problems” that cannot be solved by one discipline alone. By acting now, we can be better prepared for the future challenges of climate change and a sudden crisis of food, nutrient or energy shortages.

Keywords: Circularity, waste, energy, food production, near-zero emissions, nutrient recycling, acceptability, healthy, regulatory issues

S07-O-VII-2

The revitalization of Grozăvești Park (Bucharest, Romania) using nature-based solutions for water management

Hoble, A.[1], Morar, T.[1,2], Muraru, C.[2]

[1] Department of Horticulture and Landscape Architecture, Faculty of Horticulture and Business for Rural Development, Institute of Horticultural Research, University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, 3-5 Calea Mănăștur Street, 400372, Cluj-Napoca, Romania;

[2]Project 6 – Inovation and Urban Planning Centre, District 6 (), 147-149 Calea Plevnei Street, Bucharest, Romania, teodora.morar@proiectare6.ro

In the Romanian urban landscape, numerous open spaces of various sizes can be found, abandoned or acting as a dumpsite for construction waste materials. The revitalization of Grozăvești Park is a priority for the local public administration due to its potential role within social, economic, and environmental context. Grozăveşti Park is located within the old Cotroceni village area, which is included in the List of Historical Monuments as an archaeological site. The design concept seeks to answer the need of transit and social meet for youth people and businessmen. Also, the site has the potential to begin defining a green-blue corridor for the western area of Bucharest linking Botanical Garden, Polytechnic Campus, Dâmbovița River and Lacul Morii Park. One of the park's side overlaps with metro stations, which requires a waterproofing system, the control of rainwater, and avoidance of the ’conventional’ grey infrastructure or the technological-based solutions for green space maintenance programme. The landscape design proposal is presented based on site analyses, zone codes, and an extensive literature review, knowing that the integration of green infrastructure with sustainable drainage solutions can help to create habitat, recreational and biodiversity areas. The planting particular needs, problems and opportunities of the site were studied in detail using Google Earth Engine as the visualization platform, and satellite images from different sources: Copernicus Sentinel 2A (10 meters resolution), Spot 4 (5 meters), and Kari

KOMPSAT (2 meters). During the development of this study, the measures that restore the vitality of the neglected park, and increase site's attractiveness were ideated to recommend proper site design based on geotechnical characteristics, plant selection, and planting configuration of vegetation to enhance topsoil water retention.

Keywords: Grading plan, bioinfiltration, sustainable drainage systems, plant water requirements

S07-O-VII-3

The impact of vegetation on heat islands and thermal comfort in urban areas

Melinescu, A., Cosmulescu, S.

University of Craiova, Faculty of Horticulture, Department of Horticulture and Food Science, no. 13, A.I. Cuza Street, 200585, Craiova, Romania; melinescu93@gmail.com

Climate change and the global warming, affects the urban microclimate and represents a threat to the well-being of residents, but also a threat to the environment, therefore it's necessary to combat the phenomenon of urban heat islands, determining the temperature differences that vegetation can generate and mitigating the phenomenon by covering the urban microclimate with vegetation. The study focused on the analysis of the temperatures of various surfaces in the urban environment, in order to improve the urban microclimate. Differences of over 25˚C were observed comparing the surface temperature in the urban environment without vegetation versus a park in the city. Thus, in the design of green spaces, both public and private, it is necessary to take into account the improvement of the shading effect and absorption of solar radiation, but also energy performance, creating sustainable urban structures. The trees habitus prevents the exposure of pedestrians to solar radiation, also protecting the paved surface from heat islands, considerably increasing the thermal comfort index, observing differences of even more than 7˚C. Some tree species have a multiple contribution, both ecological, aesthetic and utilitarian, generating sustainability in urban agglomerations. The process of technology and industrialization is increasingly, cities are becoming more and more congested, and so there is a need for management plans based on combating heat waves and islands, so that residents can carry out their daily activities without endangering one's health.

Keywords: Urban horticulture, urban planning, climate changes, heat tolerance, human comfort

POSTER PRESENTATIONS

POSTER SESSION I - URBAN LANDSCAPE AND SUSTAINABILITY

S07-P-I-1

The Local Food Trace (LOFT) project: enhancing digital skills for small local food producers

Zauli, I.[1], Pennisi, G.[1], Garrido Cortés, M.[2], Oñate, P.[2], Remón, S.[2], Arisan, E.D.[3], Guary, M.[4], Ginesar, M.[5]

[1]DISTAL – Department of Agricultural and Food Sciences, Alma Mater Studiorum – Bologna University, Viale Fanin 44, 40127, Bologna, Italy; corresponding author: giuseppina.pennisi@unibo.it

[2]Instituto Agroalimentario de Aragón-IA2 (Universidad de Zaragoza-CITA) - Miguel Servet 177, 50013, Zaragoza, Spain

[3]Institute of Biotechnology, Gebze Technical University - 41400 Gebze/Kocaeli, Turkiye

[4]CDE Petra Patrimonia – 83 la Canebière, 13001 Marseille, France

[5]Kocaeli BEUFA – Governorship of Kocaeli, Bureau for EU and Foreign Affairs – Körfez Mahallesi Ankara Karayolu Caddesi 129 İzmit, Kocaeli, Turkey

Nowadays, food systems are facing major social, economic and environmental challenges. In addition, the pandemic has accelerated digitalization in all sectors and raised the demand for localized and homemade food. In this context, new opportunities for the Local Food Producers (LFPs) to reach more fruitful and close markets have been created. Local Food Trace (LOFT) is a European Union project funded by the Erasmus+ Programme. The main objective of LOFT is to contribute to European policies on digitalization and learning, through the development of digital skills of LFPs. By involving small producers in the digital transformation, one of the main goals is boosting local food production and its sustainability. In the present work, the results of a field analysis carried out among the four partner countries (Spain, Italy, Turkey and France) are presented. The research was focused on LFPs and aimed at understanding the digitalization degree and the training needs of this target group. Through a survey developed and distributed using Microsoft and Google Forms, anonymized responses were collected. Overall, 70 answers from LFPs were gathered among the 4 partners. The results displayed on one hand a current low use of digital tools by LFPs. However, the majority of LFPs showed an interest to participate in digitalization courses. These results laid the foundations for the next steps of LOFT project, which include the creation of a platform for LFPs digitalization training.

Keywords: Local food producers, digitalisation, food system, training needs

S07-P-I-2

Building for plant conservation – a case study in Romania

Paraschiv, A.M., Niță, E.

University of Bucharest, Botanical Garden "D. Brandza", 32 Șos. Cotroceni, 060114, Bucharest, Romania; anca-monica.paraschiv@g.unibuc.ro

In the big and crowded cities of the world, a large number of rooftops have been transformed into living green areas, small or large, extensive, semi-intensive or intensive, with different uses in the life of citizens. This contribution presents an example of a small, intensive rooftop garden, created on the rooftop terrace of a private house, in the city of Bucharest, with the aim of conserving plants and reconnecting people with nature. The terrace, located at a height of 10 m, on an area of 40 sqm, was build-up in 2011, using the ZinCo Technology, which ensure high water storage and a variety of substrates and depts. Using a base of 300 mm substrate, perennial plants, shrubs, and even small trees were grown on the rooftop terrace during 2012-2023. The current floristic composition (2023) includes 56 taxa of vascular plants (51 ornamental and 5 wild), belonging to 31 families of angiosperms and 3 families of gymnosperms: annual plants, geophytes, perennial herbaceous plants, subshrubs, shrubs, and trees. The criteria used in the selection and grouping of plants pertains to ecological preferences, tolerance to stressful environmental factors, plant importance, growth speed, low maintenance, spatial and seasonal diversity. The results provide an overview of the green rooftop system technology, the development of taxa introduced during a decade since the establishment of the garden and highlight the plants and combinations of plants suitable for local conditions.

Keywords: Rooftop garden, ornamental plants, wild plants, environment

S07-P-I-3

Microbiome analysis of closed and cycled organic aquaponics: comparative evaluation of different crop bedding materials

Teramoto, S.

IPDRE, Tottori University, 1390 Hamasaka, Tottori, 6800001, Japan; sasayuri18@gmail.com

Aquaponics is a sustainable and integrated agricultural system that optimally allocates essential water between fish and crop cultures. It has been developing modified aquaponics in challenging environments, including dryness, high salinity, and extreme temperatures in the Middle East, North Africa, and Central Asia, especially after the COVID-19 pandemic. The closed (water and carbon-cycled) organic aquaponics emerges as a promising solution for protected dryland kitchen gardens, showcasing minimized water usage, nutrient cycling, and contributions to household food security, particularly in fresh, nutrition-rich vegetables and herbs. Researchers have unveiled distinctive microbiomes and intricate root-soil interactions at specific sites. Conducting a target microbiome analysis focusing on bacteria may reveal samples indicative of well-functioning system parameters, bacterial group structures, and levels of biodiversity. Comprehending microbial dynamics is crucial for maintaining an optimal balance in aquaponics water and plant root environments to achieve a stable, easy, and simple

operation of the cycled aquaponics. A harmonious microbiome is pivotal for stable operations and continuous vegetable production. This study compares bacterial microbiomes and crop growth in different vegetable bedding media: sand, biochar (rice husks), cocopeat mixed with biochar (rice husks), and garbage manure. Crop bedding media using garbage manure demonstrated higher bacterial biodiversity, nitrogen-fixing bacteria volume, and crop growth than other materials. This result suggests that cycled organic aquaponics is a potential solution not only for dryland kitchen gardens.

Keywords: Bacterial Biodiversity, Bacterial group structure, Biochar, Organic bedding materials, Water and nutrient cycling

S07-P-I-4

Impact of alternating seawater and drinking water irrigation on growth of two seashore paspalum varieties in extensive green roof systems

Ntoulas, N., Kalampogias, C.

Laboratory of Floriculture and Landscape Architecture, Department of Crop Science, School of Plant Sciences, Agricultural University of Athens, Iera Odos 75, 118 55 Athens, Greece; ntoulas@aua.gr

The ongoing decline in global drinking water reserves necessitates the search for alternative water sources for irrigating turfgrass in extensive green roof systems, particularly in coastal areas in southern semi-arid Mediterranean countries. In such cases, partially irrigating green roofs with seawater could contribute to the conservation of drinking water supplies. The study aimed to assess the feasibility of using a combination of seawater and drinking water for irrigating two varieties of the warm season turfgrass *Paspalum vaginatum* Sw., 'Marina' and 'Platinum TE',' when grown in extensive green roof systems. The study involved 48 lysimeters with a 30 cm diameter, equipped with extensive green roof layering. Treatments included two substrate depths of 7.5 cm and 15 cm, along with three irrigation cycles of 1:1, 3:1, and 6:1 alternating seawater and drinking water irrigation applications, respectively. Measurements included assessing green turf cover (GTC), clipping dry weight, leaching fraction, and electrical conductivity of the leachate from the lysimeters. During the 58-day stress study, turfgrasses exhibited higher GTC values when subjected to a 1:1 irrigation cycle compared to the other two cycles. Nevertheless, none of the irrigation cycles managed to sustain GTC levels above 50% for the two varieties by the end of the study. Increasing the green roof substrate depth from 7.5 cm to 15 cm resulted in GTC improvement for both varieties. The results from the clipping dry weight aligned with the observations from GTC measurements, with the deeper substrate profiles of 15 cm and the application of the 1:1 irrigation cycle resulting in increased clipping yield for turfgrasses.

Keywords: Clipping dry weight, green turf cover, *Paspalum vaginatum*, salinity, substrate depth, turfgrass management, urban horticulture

S07-P-I-5

The role of glyphosate in urban green spaces

Kisvarga, S.[1], Horotán, K.[2], Taborska, J.[2], Hamar-Farkas, D.[1], Boronkay, G.[1], Orlóci, L.[1]

[1] *MATE, 1223 Budapest Park street 2., Magyarország; kisvarga.szilvia@uni-mate.hu*

[2] *EKKE, Eszterházy square 1. , 3300 Eger, Magyarország*

Glyphosate is one of the most widely used herbicides worldwide today. Opinions differ on the environmental impact of glyphosate. Glyphosate and its metabolite, AMPA, can accumulate in the plant and not break down. This endangers and can seriously damage the living environment and ecosystem. Continuing our previous research, we set out to examine the effect of indirectly spraying glyphosate on the leaves and soil on non-target plants in the case of *Helianthus annuus* L. plants (which are not only food plants, but also ornamental plants). We demonstrated the presence of the active substance and AMPA in the entire plant organism. Afterwards, we examined the lawn and weed associations of urban green areas treated with glyphosate to show that many ornamental plants are also damaged during the edging effect. We supplemented our measurements with morphological, histological and stress tests.

Keywords: glyphosate, AMPA, *Helianthus*, toxicology, environment, sustainability

S07-P-I-6

Sustainable landscape management strategies for the Botanical Garden and the Dendrological Park of USAMV Bucharest Campus

Vita, A.

str. Moldovita, Bucharest, Romania; ana.vita1995@gmail.com

The development of information technologies offers new methods for inventorying and assessing the state of vegetation. Thus, we can map and monitor the evolution of plant habitats in urban areas. The aim of the study is to use vegetation inventory software in order to achieve a sustainable management plan for urban green areas.
In this case, the inventory of the trees was made in the botanical garden and the dendrological park located in the campus of the University of Agronomic Sciences and Veterinary Medicine from Bucharest. A database which contains the existing trees was created through a tree inventory software application (Tree Plotter).
The inventory database will be used to develop a sustainable management plan for the studied area. Based on the data entered, a series of differentiated plans resulted, concerning the following aspects: the spatial distribution of the invasive species, the specimens with a precarious state of health, the ecological benefits provided by the trees, etc. Following these results, specific strategic directions of landscape management were elaborated depending on the characteristics of the inventoried specimens and the areas in which these trees are located. These refer to permanent management activities, such as: pruning regime, irrigation regime, ecological phytosanitary treatments, but also a series of occasional measures, such as: combating invasive species depending on their spatial distribution; reorganization of the vegetation structure according to the problems identified following the inventory; protection of affected or endangered plants by anchoring; short, medium and long term monitoring of the dendrological vegetation in order to update the management plan.

The development of a sustainable landscape management strategy can contribute to improve the quality of the environment and the level of biodiversity, increasing as well as the level of economic efficiency, but also the aesthetic and functional attractiveness of green spaces in general.

Keywords: Landscape management, botanical garden, dendrological park, sustainability, trees management, vegetation inventory

S07-P-I-7

Use of nutrient solution and greywater for aeroponic and hydroponic cultivation of chicory grown on lightweight urban green roof

Paradimitriou, D.[1], Nektarios P.A.[2], **Harkoutsis, D.[2]**, Daskalaki, C.[2], Markakis, N.[1], Manios, T.[1], Daliakopoulos, I.N.[1]

[1]Utilization of Natural Resources and Agricultural Engineering Laboratory, School of Agricultural Sciences, Department of Agriculture, Hellenic Mediterranean University, 71004, Crete, Greece;

[2]Quality and Safety of Agricultural Products, Landscape and Environment Laboratory, School of Agricultural Sciences, Department of Agriculture, Hellenic Mediterranean University, 71004, Crete, Greece. harkoutsis@gmail.com

Green roofs can support urban food production with the additional benefits of being removed from primary urban pollution sources and facilitating a better controlled environment, thus promising, apart from enhanced food security, improved produce quality and sustainability. Soilless cultivation methods, such as hydroponics and aeroponics, offer an additional level of control that is pertinent to urban agriculture. The present study used 18 outdoor lysimeters of 2 × 1 m equipped with load cell sensors simulating building green roof systems (GRS). The lysimeters were used to examine the capacity of hydroponic and aeroponic systems to produce chicory (Cichorium intybus) when irrigated with either nutrient solution or greywater. Treatments included (a) a hydroponic system with bags filled with agricultural perlite as growing medium, (b) an aeroponic system using a polystyrene cap as container allowing the unrestricted development and mechanical support of the root system in the air, (c) irrigation with modified Hoagland nutrient solution and (d) irrigation with greywater collected from a private house. Each treatment was replicated 3 times (2 systems × 2 irrigation sources × 3 replications = 12 lysimeters). In each lysimeter, 18 lettuce plants were planted. Four additional lysimeters served as unplanted irrigated controls and two empty lysimeters simulated a conventional rooftop, totalling 18 lysimeters. Measurements were performed in 4 central plants within each lysimeter and included plant height and growth index, leaf stomatal conductance, SPAD, leaf fluorescence, pH, and EC of the effluent. The weight fluctuation of each treatment was determined using weighing lysimeters equipped with load cells in conjunction with real time effluent volume determination using tipping buckets. Weighing was averaged though a junction box and transmitted using Arduino while tipping bucket data was transmitted through PLC. During the experiment, drainage pH and EC for greywater (8.6 -8.8 and 0.6-0.7 dS m-1, respectively) and nutrient solution (6.2-6.4 and 1.8 dS m-1, respectively) remained within the acceptable range for chicory growth. SPAD, stomatal conductance and relative chlorophyll fluorescence measurements in the hydroponic treatments were significantly higher than those in the aeroponic treatments, however chicory growth was acceptable only for the fertigated

hydroponic treatment (49.9 g plant-1) and greywater and aeroponics proved inadequate to support successful cultivation. While the aeroponic system was not able to support chicory growth under any treatment, it proved extremely lightweight at 5.8-8.3 kg m-2 compared to the hydroponic system at 26.1-44.2 kg m-2 indicating the need to improve cultivation practice performance to develop successful lightweight GRS.

Keywords: Adaptive green roof systems, Mediterranean zone, substrate depth, substrate type, native plant species, deficient irrigation, drought tolerance.

S07-P-I-8

Comparison of different substrates for plant growing in containers in urban horticulture

Zeipina, S.[1], Ievina, L. [2], Lakovskis, P. [2], Lepse, L.[1]

[1]*Institute of Horticulture, Dobele, Latvia; solvita.zeipina@lbtu.lv*

[2]*Institute of Agricultural Resources and Economics, Riga, Latvia.*

Urban horticulture has an important role to play in the response to the growing challenges of global urbanization, including food security, environmental sustainability and human well-being. Urban gardening includes a wide range of practices and systems: kitchen gardening, community gardens, terrace gardening, landscape gardening, container plantings, herb gardens, meditation gardens, vertical farms etc. Vegetable cultivation in containers provides an effective solution for utilizing limited urban space and allows individuals to grow their own fresh products in a controlled environment (on roofs, terraces, balcony, etc). The choice of substrates for vegetable growing in containers is an important factor in successful urban agriculture. It comprises with two different challenges – substrate has to be suitable for plants growth and maximally reduced weight, as often the containers are placed on the buildings. One of the main components used for the substrates for containers until now is peat. However, the using of peat in horticulture is going to be minimized due to its slow renovation as natural resource. The investigations were carried out in two locations: at the Institute of Horticulture and Institute of Agricultural Resources and Economics, Latvia, during the growing season of 2023. Research carried out within the project “Influence of agroecological conditions on the quality of vegetables in urban horticulture (Roof2Fork)”, financed by Latvian Council of Science. Vegetable crops (radish, peas, lettuce, basil) were grown in wooden containers of 336 L volume. Three different substrates were compared with the aim to deminish peat usage in horticulture – peat: perlite = 4:1, peat:coconut fibre = 1:1, and peat:hempseed sheaves = 1.5:1. Smaller plants and consequently significantly lower yields were obtained in the variant of peat : hempseed sheaves substrate for all crops. Both other substrates did not differ significantly in terms of vegetable yield.

Keywords: Substrate, containers, peat, hempseed sheaves, coconut fibre, perlite

Poster session II - Vertical farming and urban horticulture

S07-P-II-1

Cutting propagation of woody plants in indoor vertical farming

Nozue, H.[1], Takamizawa, H.[2], Shirai, K.[1], Kaiga, J.[1], Miyamoto, H.[3], Iwaoka, A.[3]

[1] *Shinshu University, 3-15-1 Tokida, Ueda city, Nagano 386-8567, Japan; htmi-kj@shinshu-u.ac.jp*

[2] *1605-14, Nagano, Japan*

[3] *3039 Sasaga, Matsumoto, Japan*

Stem cutting is broadly applicable method as vegetative propagation. Meanwhile, indoor culture became known as one of safety, sustainable and useful agricultural system. This study was aimed to evaluate root-forming efficiency in indoor cultivation with cutting materials from woody plants, such as fruit, ornament and forest trees. The vertical farm was constructed in indoor space controlled at 22±2℃ temperature and 45-60% humidity. Water bath filling with soilless plastic medium (Sophiterra®, Kuraray Japan) was used as hydroponic medium to promote rooting. The baths were placed on the shelves and automatically irrigated at scheduled time. White LEDs of variable spectrum distribution were chosen as lighting source. Light intensity adopted for incubation of hydroponic treatment of cuttings was 50-80 μmolm-2s-1. Photoperiods of long-day (16h/day) and short-day (8h/day) were set up. In comparison between differently controlled lighting groups, it revealed that the period needed to induce rooting on cuttings can be controlled by light color and daytime. As a result, root formation was significantly enhanced by near-infrared wavelength light and short-day treatment. The data suggested that the same tendency associate with lighting was observed regardless of species and seasons of sampling materials. Condition of indoor cultivation we constructed here is not strictly controlled, and the system is economically applicable everywhere in the world. The present study also shows the additional merit of this method is useful without hormone treatment. We hope it will provide great benefit for dissolving agriculture and environment-related matter.

Keywords: Stem cutting, light color, day time, hydroponics, soilless medium

S07-P-II-2

Flavor profiling in Vertical Farms: An exploration study of Fresh Basil Tasting Method

Qianxixi Min[1], Liu, Y.[1], Jacobs, D.M.[2], Knoop, M.[2], Geerdinck, L.[3], Jancic, A.[3], Nicole, C.[3], Papaspyrou, N.[4], Huntenburg, K. [1], Woltering, E. [1], **Marcelis, L. [1]**

[1] *Droevendaalsesteeg 1, 6708PB Wageningen, Netherlands; leo.marcelis@wur.nl*

[2] *Bronland 14, 6708 WH, Wageningen, Netherlands*

[3] *High Tech Campus 48, 5656 AE Eindhoven, Netherlands*

[4] *Keienbergweg 26, 1101 GB Amsterdam, Netherlands*

Basil, increasingly grown in controlled environment agriculture, is well known for its rich flavor and aroma profile, which are essential to its commercial value. Limited research has been done to recognize the complex sensory attributes of fresh basil cultivated in vertical farms. Our study aimed to apply a sensory methodology to assess flavor profiles of plants grown under various cultivation conditions. Using retail fresh basil and standard flavor solutions as references, the key sensory attributes and a unified scoring criteria for panelists were established under blind conditions. These attributes included the intensity of odor, flavor, sweetness, bitterness, floral notes, spiciness and pepperiness, herbal and green notes, anise and licorice, mint, off-flavors, and aftertaste. Our approach of quantitative descriptive analysis effectively distinguished the key sensory attributes of various basil cultivars. Duplicated descriptive paired comparison were then conducted in blinded tests to identify detailed flavor differences under different cultivation treatment with a semi-trained panel of 7 tasters, including the flavor variations due to plant and leaf age, cultivation environments (greenhouse versus vertical farms), and specific lighting conditions (with and without far-red light in two different commercial vertical farms). This approach highlighted the impact of leaf ages and far-red light on fresh basil's sensory properties. These findings also highlight significant potential for optimizing basil's commercial cultivation, potentially leading to improved flavor in controlled environments.

Keywords: Basil Flavor, Far-Red Light, Taste Panel, Vertical Farm, Sensory Analysis

S07-P-II-3

Vertical stacking of NFT hydroponics in naturally lit polytunnels using low-cost materials increases yields of baby gem lettuces

Evans, T.[1], Leake, J.[2], Nickles, J.[3], Selby, M.[4]

[1] 298 School Road, S10 1GR Sheffield, United Kingdom; tpevans1@sheffield.ac.uk

[2] Firth Court. Western Bank, S10 2TN Sheffield, United Kingdom

[3] University of Manchester, Oxford Rd, M13 9PL Manchester, United Kingdom

[4] Arthur Wilis Environment Centre, 1 Maxfield Avenue, S10 1AE Sheffield, United Kingdom

In many urban and peri-urban locations access to space can be a limiting factor for the amount of produce that can be grown, with the use of multiple layers being a common solution to this problem. Supplementary lighting is often used when growing systems are located indoors or if the vertical stacking creates shading upon lower layers, this however comes with significant upfront and ongoing costs that can be prohibitive for smaller growers. Increasing planting density without increasing energy consumption from LEDs could be a promising avenue to more sustainable hydroponics systems at the small-medium scale.

In this study, two-layer Nutrient Film Technique (NFT) hydroponic systems using low-cost, off the shelf materials were constructed to assess their total shoot fresh weight (SFW) yield per m2 of baby gem lettuces compared to a single layer control in an unheated, naturally lit plastic polytunnel. All systems consisted of 5 channels on their lower layer with the two treatments having either 3 or 5 channels ('3/5' and '5/5', respectively) on their upper layer; the control had no upper layer ('0/5').

The highest density planting from the 5/5 system resulted in the highest total SFW per m2 (10.3 kg) despite the reduced irradiance measured on the bottom layer when compared to the 3/5 and 0/5 systems. This suggests that when cost and space are

constraints and yields are a priority, unlit vertical stacking can be an appropriate approach. Investigation into other physiological measurements of the lettuces to establish optimal channel spacings in vertically stacked systems will help to produce maximum yield at maximum quality.

Keywords: Vertical Farming, Sustainability, Low-cost, Low-tech, Lettuce, Low-input, Energy, Urban Agriculture, Controlled Environment Agriculture, Polytunnels

S07-P-II-4

Low-requirement plants for energy savings in indoor vertical gardening systems

Iglesias Diaz, I.[1], López-Fabal, A.[1], Lamosa-Quinteiro, S.[1], López-López, N.[2], Lago-Pena, F.[1], García-López, P.[1]

[1]Escuela Politécnica Superior de Ingeniería, Universidade de Santiago de Compostela, Lugo, Spain; mariaisabel.iglesias.diaz@usc.es

[2]Biofusiónate. CEI-NODUS. Centro de Empresas e Innovación, Lugo, Spain

Vertical gardening has environmental impacts associated with both its establishment and its subsequent use. This impact can be reduced by using plants with low environmental requirements, both at the production and maintenance levels. To this end, they were selected species that can be produced in undemanding conditions, particularly in unheated greenhouses in temperate zones, and their speed of surface covering and adaptation to low lighting conditions were tested. Based on the first criterion, 10 species were selected: *Ajuga reptans, Brachyscome angustifolia, Coprosma × kirkii, Felicia amelloides, Hedera helix, Lavandula angustifolia, Phlox subulata, Pelargonium peltatum, Sedum rupestre* and *Sedum spurium*. With them, a test was carried out under controlled conditions in phytotron using a recirculating hydroponic system consisting of trays filled with expanded clay with 12 plants per tray spaced 12 cm and 3 repetitions per species. In a first phase, the growth and coverage of the plants was measured in good lighting conditions (3000 lux), followed by two phases with progressive reduction of light to 900 and 500 lux; each of the phases lasted approximately 3 months. The coverage of the surface by the plants was measured by image analysis. In the phases of light reduction, the length of internodes and the chlorophyll content were measured (when possible) and a visual evaluation of the growth habit, ornamental value and the incidence of pests and diseases was also carried out. *Ajuga* and *Pelargonium* were the species that achieved a coverage of 80% in the shortest time, followed by *Sedum rupestre*, while *Brachyscome*, *Coprosma* and *Phlox* were the slowest to cover. The reduction of light to 900 and especially to 500 lux resulted in changes of growth habit and increased the incidence of fungal diseases and attacks by aphids and whiteflies.

Keywords: Light, hydroponics, coverage, chlorophyll content, image analysis

S07-P-II-5

BEST Microgardens – Elaboration of an online platform to mitigate food insecurity in urban areas

D'Aprile, A.[1], **Carotti, L.[1],** Pennisi, G.[1], Morelli, A.[1], Pérez Garcias, A.[2], Yfantopoulos, D.[3], Mellara, M.[4], Rossi, A.[4], Guary, M.[5], Begun, M.[6], Orsini, F.[1]

[1] *Alma Mater Studiorum – University of Bologna, DISTAL – Department of Agricultural and Food Science, Viale Giuseppe Fanin 44, 40127, Bologna, Italy;* corresponding author: giuseppina.pennisi@unibo.it

[2] *Universitat de les Illes Balears, Carretera de Valldemossa, km 7.5, Nord, 07122 Palma, Illes Balears, Spain*

[3] *Laboratory of Vegetable Production, Department of Crop Science, Agricultural University of Athens, Iera Odos 75, 11855 Athens, Greece*

[4] *Mammut Film, Via Giovanni Brugnoli 7/A, 40122, Bologna, Italy*

[5] *Petra Patrimonia Corsica, Couvent des Capanelle, Route de Ville 20200, Bastia, France*

[6] *Elderberry AB, Mickelsbergsvägen 134, 12950 Hägersten, Sweden*

Food insecurity is a major problem in densely populated areas of the world. The growth of cities and erosion of rural environments have increased the distance between agricultural products and consumers. Accordingly, it is increasingly more difficult to find fresh vegetables at low prices and this has a high impact on the health of the less-advantaged people. In this context, urban agriculture has the potential to reduce the distance between the producers and the final consumers and increase the freshness of the products. The Erasmus+ project “BEST Microgardens” (KA220-ADU – Cooperation partnerships in adult education) has the goal to provide the correct instruments to convert small spaces, like balconies or gardens, into productive microgardens (small plots of land, a vase or a hydroponic system used to produce food). With this aim, a consortium of six partners from five different countries (Italy, France, Spain, Greece, and Sweden) have worked together to implement an online platform that could be used by users and trainers to teach or learn several different aspects about microgardening. Thanks to the use of the platform, stakeholders will gain knowledge from sowing to marketing, including communication and networking. With short video tutorials and a system of knowledge checks, the BEST Microgardens platform will be an important instrument to help people grow their own food in urban areas.

Keywords: urban agriculture, training, b-learning, microgardening, education

S07-P-II-6

Effects of organic fertilizers on lettuce cultivation in a high-humidity environment assuming large-scale plant factories with artificial lighting

Eguchi, M.[1], Lin, B.[2], Nakamura, K.[2], Kitaya, Y.[1]

[1] *Research and Development Center for Plant Factories, Osaka Metropolitan University, Sakai, Japan; Masatake.Eguchi@gmail.com*

[2] *Espec Mic Corporation, Osaka, Japan.*

To reduce environmental impacts and realize sustainable food production, plant factories with artificial lighting (PFALs) need to use organic fertilizers in the near future though chemical fertilizers are currently primarily used. Shinohara (2006) developed a method for simultaneous ammonification and nitrification in a solution containing organic

fertilizers and succeeded in cultivating plants hydroponically using organic fertilizers, which was considered nearly impossible. Because of the closed environment and high plant density in PFALs, relative humidity tends to be high, often approaching 100%. Because a high-humidity environment inhibits transpiration and reduces nutrient uptake, organic fertilizers, which contain more non-nutrient substances than those in chemical fertilizers, are likely to cause poorer growth and physiological disorders. In this study, lettuce was cultivated using organic fertilizers such as waste liquid from dried bonito production and oyster shell lime according to the method developed at the National Agriculture and Food Research Organization by Shinohara et al. (2014) in a high-humidity environment with a relative humidity of at least 85% to obtain the basic information for introducing organic fertilizers into PFALs. The results of this study suggest that adjusting the amount of nitrogen in waste liquid from dried bonito production to at least 6 mg per plant per day produces yields close to those obtained from cultivation with chemical fertilizers with conventional concentration under long-day and high-humidity conditions, such as PFALs. Although more detailed studies are needed, water absorption may be easily inhibited in plants grown with organic fertilizers, and care is needed regarding with the composition and amount of organic fertilizers used to prevent the induction of physiological disorders.

Keywords: Plant factory with artificial lighting, vertical farm, organic fertilizer, physiological disorder

S07-P-II-7

Growth requirements for space cultivation of microgreens as fresh food to integrate the astronauts' diet

Paradiso, R.[1], Amitrano, C.[2], Paglialunga, G.[3], Battistelli, A.[3], De Micco, V.[2], Del Bianco, M.[4], Pannico, A.[2], Moscatello, S.[3], Proietti, S.[3], Rouphael, Y.[2], De Pascale, S.[2]

[1] University of Naples Federico II, Plant Biology and Crop Science, Via Università 100, 80055 Portici, Naples, Italy; rparadis@unina.it

[2] Piazza Carlo di Borbone 1, 80055 Portici, Naples, Italy

[3] Via G. Marconi n. 2, Porano, Terni, Italy

[4] Via de Politecnico, Roma, Italy

During long-term manned missions beyond Low Earth Orbit (e.g., on Mars), integrating the astronauts' diet with fresh, nutrient food, rich in functional compounds, like microgreens, could serve as a preventive countermeasure against the oxidative stress caused by the exposure to space conditions. Hence, the definition of specific cultivation protocols becomes essential in plant modules within bioregenerative life support systems (BLSSs), where the small volume and the closed environment could impact plant anatomy, physiology, and resource utilization, with crop-specific responses.
We evaluated how two vapor pressure deficit (VPD) levels, 0.14 kPa (LV) and 1.71 kPa (HV), and two light intensities, 150 (LL) and 300 (HL) µmol m−2 s−1, influenced the growth, morpho-anatomical parameters, and nutritional properties of two microgreen species, cabbage (*Brassica oleracea* var. *capitata* f. *sabauda* 'Vertus') and radish (*Raphanus raphanistrum* subsp. *sativus* 'Saxa'). Microgreens were grown on coconut fiber mats, under controlled conditions (temperature 18/24°C, red-green-blue light spectrum R45:G10:B45, and photoperiod 12 h), and monitored until the emergence of the first true leaves.

While differences in growth primarily stemmed from the plant species, with cabbage showing the highest fresh and dry weight, and a greater length, both VPD and light intensity influenced the anatomical traits and the content of various compounds, including ascorbic acid, carbohydrates, nitrate, and phosphate. Specifically, low VPD and low light intensity increased the tissue thickness and promoted the synthesis of b-carotene and photosynthetic pigments, in both cabbage and radish. Besides, cabbage under LV-LL showed the highest content of ascorbate, which is a fundamental nutritional attribute in space conditions. Moreover, the effects of the treatments and their interaction also implied relevant differences in the resource use efficiency.
Our results confirm the viability of microgreens for cultivation within confined growth modules in space missions, provided that the environmental factors are carefully adjusted to meet species-specific requirements, thereby optimizing the biomass production and enhancing nutraceutical properties.

Keywords: Bioregenerative life support systems (BLSSs), cabbage, Brassica oleracea var. capitata f. sabauda, radish, Raphanus raphanistrum subsp. sativus, light intensity, vapor pressure deficit (VPD), morpho-anatomical traits, antioxidants

S07-P-II-8

Influence of LED lamps and biostimulants on the characteristics of Brassicaceae microgreens

Toscano, S.[1], **Ferrante, A.[2],** Romano, D.[3]

[1] *Department of Veterinary Science, Università degli Studi di Messina, 98168 Messina, Italy*

[2] *Scuola Superiore Sant'Anna Pisa, Crop Science Research Center, via Alamanni 22, Ghezzano (PI), Italy, antonio.ferrante@santannapisa.it*

[3] *Department of Agriculture, Food, and Environment, Università degli Studi di Catania, 95131 Catania, Italy*

To evaluate the influence of light of different wavelengths and biostimulants on the yield and qualitative characteristics of radish and turnip green microgreens, two trials were conducted in an indoor environment. In the first trial conducted on radish and turnip green, three levels of light radiation were compared: red, blue, and green. In the second trial, conducted on turnip green, the effects of different light radiations on interaction with biostimulants based on moringa and borage leaf extracts were analysed in a factorial design. The results of the first trial highlighted how red light in radish increased fresh biomass. Variations in pigments did not appear to be substantial, although they were significant. The DPPH content was slightly higher for plants that benefited from blue and green radiation than for those that benefited from red radiation. The polyphenol content was lowest in the microgreen samples obtained under green light and reached the highest values under red light. In turnip greens, an increase in fresh biomass (+ 50.0%) was observed with red light, whereas no differences were observed due to the effect of biostimulants. The factors under study determined slight and not always significant differences in the pigments. The effects of LED and biostimulants (second trial) have mainly focused on the content of health-promoting substances. DPPH increased following treatment with green and blue light, and moringa. The polyphenol content showed significant variation owing to interactions between the factors under study. The total sugar content benefited from the use of biostimulants, particularly moringa,

especially red light. Ascorbic acid content was higher under blue light. The nitrate content showed marked variation as a result of all studied factors and their interactions. Red light showed a significant reduction (43.5%) compared to the value (1.181 mg kg-1 FW) recorded with blue light. Among the biostimulants, moringa increased the nitrate content by 24.9% compared to that of the control; the increase caused by moringa was greater with green light.

Keywords: Antioxidant, indoor environment, lighting, quality, plant-derived biostimulants, radish, turnip green.

S07-P-II-9

Effect of LED lamp color temperature on *Anthurium andraeanum* growth and flowering in indoor living walls

Ntoulas, N., Ntella, N., Papafotiou, M.

Laboratory of Floriculture and Landscape Architecture, Department of Crop Science, School of Plant Sciences, Agricultural University of Athens, Iera Odos 75, 118 55 Athens, Greece, ntoulas@aua.gr

When living walls are installed indoors, the application of artificial lighting is essential to ensure satisfactory growth and flowering of plants. In this study, the effect of different LED lamp color temperatures on the growth and flowering of *Anthurium andraeanum* Linden ex André (Flamingo Flower) in indoor living walls was evaluated. The study was conducted in an enclosed space at the Laboratory of Floriculture and Landscape Architecture at the Agricultural University of Athens and lasted for 7 months. The three types of LED lamps evaluated in the study were: a) warm lighting 2700 K, b) neutral lighting 4000 K, and c) cool lighting 6500 K. The effect of different LED lamp color temperatures on the plants was assessed by determining the plant coverage, leaf color, and number of flowers. A gradual increase in plant coverage was observed in all three types of lighting, with neutral and cool lighting exhibiting higher values compared to warm lighting. The green color of the plant leaves remained relatively stable throughout the study for all three types of lighting. In contrast, the number of flowers on all plants decreased during the study. On the last sampling date, an average number of flowers was recorded, equal to two flowers for cool and warm lighting and three flowers for neutral lighting. It is worth noting that the initial average number of flowers for all three types of lighting was similar and equal to twelve flowers.

Keywords: Biophilic design, flamingo flower, ornamental lighting, urban greening, vertical greening systems

S07-P-II-10

Effects of red-blue ratio of supplemental LED lighting on plant growth and tuber yield in potato cultivars

Paradiso, R.[1], Pannico, A.[2], Arouna, N.[2], Caporale, A.[2], De Pascale, S.[2]

[1] University of Naples Federico II, Plant Biology and Crop Science, Via Università 100, 80055 Portici, Naples, Italy; rparadis@unina.it

[2] Piazza Carlo di Borbone 1, 80055 Portici, Naples, Italy

Light spectral composition influences plant growth and product yield in many plant species, however only a few data on plant response to light spectrum are available for potato (*Solanum tuberosum* L.), as it is usually cultivated in open field.
We investigated the influence of plant genotype and light spectrum of supplemental artificial lighting on plant growth and physiology of potato, grown in pot in unheated greenhouse, in winter-spring period. Two plots were equipped with 30% shading nets and an automated system with light emitting diodes (LEDs). A control system regulated the LED emission under the shaded plots based on PAR sensors in the unshaded control. The effects of two treatments with red (R) and blue (B), ratios RB1:1 and RB2:1, reintegrating the reduced sunlight intensity, compared to sunlight (CNT) were evaluated in two cultivars, 'Colomba' and 'Libra', in terms of plant growth, leaf photosynthesis and photochemistry and tuber yield.
In CNT plants, net photosynthesis (NP) was similar in the cultivars, while aerial biomass accumulation and tuber yield were greater in 'Libra'. In 'Colomba', NP and plant leaf area were unaffected by lighting treatments, however the tuber yield increased under RB 2:1 light integration. Conversely, in 'Libra' both the aerial biomass and the tuber production decreased with RB 2:1 light. The dry matter partitioning revealed a higher harvest index in 'Colomba', and similar values within each cultivar in all the lighting conditions.
Potato tubers of 'Colomba' showed higher content of all the nutrients, except P and Cu, than 'Libra', presumably because of different genetic traits and a slightly lower tuber biomass (concentration effect). Supplemental RB light did not alter the mineral composition of tubers compared to sunlight.
Our results showed a genotype-specific response to light quality in potato, highlighting the need of preliminary characterization of cultivar sensitivity to light spectrum to develop efficient protocols for artificial lighting.

Keywords: *Solanum tuberosum* L., greenhouse, light spectrum